In addition, to increase reliability of diagnosis, the system provides a means to determine each failure mode.

Reference signs show the following parts: 1··· engine, 2···cylinder, 12···fuel pump, 13 ···injector, 14··· variable fuel pressure regulator, 15···control unit, 16 ···crank angle sensor, 17···ignition coil, 21···fuel pressure sensor, 24···CPU, 32···booster circuit, 33··· upstream switch element for valve-opening, 34···upstream switch element for holding the valve, 35···back-current prevention element, 36···switch element for sink, 38··· reflux element, 39···control section, 40···reference current generating section, 41···diagnostic section, 42 ···SPI section.

The present invention provides a fuel supply system that can diagnose the fuel supply system itself as well as protect the fuel supply system itself.

WHAT IS CLAIMED IS:

1. A fuel supply system comprising:

means for detecting operating condition of an engine;

means for calculating the width of the fuel injection pulse based on the detected operating condition, the fuel injection pulse including valve-opening signal and holding signal;

means for supplying valve-opening current to the solenoid located in a fuel injector based on the fuel injection pulse width;

means for supplying solenoid holding current to hold the valve-opening condition after the valve-opening current has reached a predetermined current value;

wherein said fuel supply system supplies current to said solenoid when the logical product of said valve-opening signal and said holding signal has been formed; and

wherein said fuel supply system diagnoses an abnormality of the fuel injector when the time period from the start of said fuel injection pulse until said valve-opening current reaches the predetermined current value is shorter than a predetermined time period.

2, A fuel supply system according to Claim 1, further comprising:

battery voltage;

a booster circuit for generating voltage larger than the battery voltage from said battery voltage;

a first switch for supplying current from said booster circuit to said solenoid;

a second switch for supplying current from said battery voltage to said solenoid;

a third switch for sinking current from said solenoid toward the ground direction; and

a flywheel circuit for supplying current to said solenoid, when said first switch and said second switch are OFF, by directing current from the ground through said solenoid located in the fuel injector and then through said third switch and returns it to the ground; and

wherein said fuel supply system shut down said first switch through said third switch when an abnormality is determined in said solenoid.

3. A fuel supply system according to Claim 2, wherein the recovery timing after said first switch, said second switch and said third switch have been shut down is the timing at which the next fuel injection starts.

4. A fuel supply system according to Claim 2, further comprising:

means for detecting current flowing through each of said first switch and said third switch; and

when the logical product of said valve-opening signal and said holding signal has been formed and when current flowing through either said first switch or said third switch remains larger than the predetermined value for a duration that is longer than the predetermined time,

said fuel supply system shutting down either said first switch or said third switch.

5. A fuel supply system according to Claim 4, wherein the recovery timing after said first switch and said third switch have been shut down is the timing at which the next fuel injection starts.

6. A fuel supply system according to Claim 2, further comprising means for detecting current flowing through each of said second switch and said third switch; and

when said valve-opening signal is OFF and said holding signal is ON and when current flowing through either said second switch or said third switch remains larger than the predetermined value for a duration that is longer than the predetermined time,

said fuel supply system shutting down either said second switch or said third switch.

7. A fuel supply system according to Claim 6,

wherein the recovery timing after said first switch and said third switch have been shut down is the timing at which the next fuel injection starts.

8. A fuel supply system comprising:

means for detecting operating condition of an engine;

means for calculating the width of the fuel injection pulse based on said detected operating condition, the fuel injection pulse including a valve-opening signal and a holding signal;

means for supplying valve-opening current to the solenoid located in the fuel injector based on the fuel injection pulse width, and

means for supplying solenoid holding current for holding the valve-opening condition after said valve-opening current has reached the predetermined current value; and

wherein said fuel supply system supplies current to said solenoid when the logical product of said valve-opening signal and said holding signal has been formed; and

said fuel supply system detects that valve-opening current is insufficient when said valve-opening current flowing through said solenoid has not reached the predetermined current value when said valve-opening signal is terminated.

9. A fuel supply system according to Claim 1,

wherein said fuel supply system detects that holding current is insufficient when holding current more than the predetermined current value does not flow through said solenoid when said holding signal is terminated.

10. A fuel supply system according to Claim 2, further comprising:

a constant voltage source,

a constant current source, parallel connected to said third switch, for supplying current from said constant voltage source, and

a voltage detector for detecting voltage of said third switch; and

when said first switch through said third switch have been turned OFF and when voltage detected by said voltage detector is higher than the predetermined voltage, said fuel supply system diagnosing an abnormality of the fuel injector.

11. A fuel supply system according to Claim 2, comprising:

a constant voltage source,

a constant current source, parallel connected to said third switch, for supplying current from said constant voltage source, and

a voltage detector for detecting voltage of said third switch; and

when said first switch through said third switch have been turned OFF and when voltage detected by said voltage detector is lower than the predetermined voltage, said fuel supply system diagnosing an abnormality of the fuel injector.

12. A fuel supply system comprising:

means for detecting operating condition of an engine;

means for calculating the width of the fuel injection pulse, consisting of two signals: valve-opening signal and holding signal, based on said detected operating condition;

means for supplying valve-opening current to the solenoid located in the fuel injector based on said fuel injection pulse width, and

means for supplying solenoid holding current for holding the valve-opening condition after said valve-opening current has reached the predetermined current value; and

said fuel supply system supplying current to said solenoid when the logical product of said valve-opening signal and said holding signal has been formed; and

said fuel supply system diagnosing an abnormality of the fuel injector when the time period from the start of said fuel injection pulse until said valve-opening current reaches the predetermined current value is shorter than the predetermined; wherein

the formation of the logical addition of said valve-opening signal and said holding signal is accepted only once each time when said holding signal is turned ON.

13. A fuel supply system according to Claim 2, wherein said first switch and said second switch are disposed for each opposed cylinder, and when the ON timing of the opposed cylinder's third switch coincides, the switch 3 which has been turned ON earlier is turned OFF.

14. A fuel supply system according to Claim 2,

when any one of said first switch through said third switch is shut down and said valve-opening current flowing through said solenoid has not reached the predetermined current value when said valve-opening signal is terminated,

said fuel supply system detecting insufficient valve-opening current.

15. A fuel supply system according to Claim 4,

said fuel supply system stopping detecting insufficient valve-opening current during the fuel injection pulse when either said first switch or said third switch is shut down.

16. A fuel supply system according to Claim 2, said fuel supply system stopping detecting insufficient holding current during the fuel injection pulse when said first switch through said third switch are shut down.

17. A fuel supply system according to Claim 6, wherein said fuel supply system stops detecting insufficient holding current during the fuel injection pulse when either said second switch or said third switch is shut down.

18. A fuel supply system according to Claim 13, wherein said fuel supply system stops detecting insufficient holding current during the fuel injection pulse when said third switch is shut down.